RAPID MORTALITY SURVEILLANCE REPORT 2012

Rob Dorrington,
Debbie Bradshaw,
Ria Laubscher

Burden of Disease Research Unit
Medical Research Council

February 2014

SOUTH AFRICAN MEDICAL RESEARCH COUNCIL

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ACRONYMS AND ABBREVIATIONS

q_0	-	probability of a live birth dying before age 1
$_5q_0$	-	probability of a live birth dying before age 5
$_{45}q_{15}$	-	conditional probability of a 15-year-old person dying before age 60
AIDS	-	acquired immune deficiency syndrome
ASSA	-	Actuarial Society of South Africa
HIV	-	human immunodeficiency virus
DHA	-	Department of Home Affairs
DHIS	-	District Health Information System
DNF	-	death notification form
e_0	-	life expectancy at birth
e_{60}	-	life expectancy at age 60
HDACC	-	Health Data Advisory and Coordinating Committee
ICD	-	International Statistical Classification of Diseases and Related Health Problems
ID	-	identity document
IMR	-	infant mortality rate
MMIEG	-	Maternal Mortality Interagency Estimation Group
MMR	-	maternal mortality ratio
MRC	-	Medical Research Council
NMR	-	neonatal mortality rate
NPR	-	National Population Register
NSDA	-	Negotiated Service Delivery Agreement
PRMR	-	pregnancy-related mortality ratio
RMS	-	Rapid Mortality Surveillance
Stats SA	-	Statistics South Africa
U5MR	-	under-5 mortality rate
VR	-	vital registration
WPP	-	World Population Prospects (2012 revision)

EXECUTIVE SUMMARY

This is the second report based on the Rapid Mortality Surveillance (RMS) system. Originally set up to monitor the trend in adult deaths recorded on the National Population Register at a time when there was a substantial time lag in the cause-of-death reports produced by Stats SA, the RMS still provides timely empirical estimates of the mortality-based high-level indicators for Outputs 1 and 2 of the health-related targets of the Negotiated Service Delivery Agreement (NSDA) up to 2012.

By making adjustments for known bias in the RMS data, it is possible to provide information about these key indicators two years sooner than would have been the case if relying on the published cause-of-death data. Estimates of the neonatal mortality rate (NMR) and the maternal mortality ratio (MMR) cannot, however, be obtained from this source. The NMR up to 2012 is based on adjusted data from the District Health Information System (DHIS) and the MMR on adjusted data from cause-of-death data from Stats SA up to 2010.

The 2011 Census population estimates released by Stats SA late in 2012 indicate that the population size was quite different in some respects from what was expected. The age distribution of the population below the age of 30 and the overall size of the population were particularly different. It was therefore decided that this new population information needed to be allowed for in estimating the mortality indicators. Population estimates and the number of births that are consistent with the age distribution and total population size from the 2011 Census have been used for calculating rates. In order to have a consistent series of estimates, it was necessary to re-estimate the indicators for previous years and targets to be consistent with those for 2012, including values for the baseline year 2009.

The estimates for 2012 show that the average life expectancy in South Africa has reached 61 years, an increase of 7 years since the low in 2005. The increase in life expectancy was due to a drop in the levels of child mortality as well as young adult mortality. In 2012, there was a continued reduction of young adult mortality. However, compared to the levels in 2011, infant and child mortality rates have stagnated. Neonatal mortality rates have improved slightly since 2009 and are currently 12.46 per 1 000 live births, still above the NSDA target. The maternal mortality ratio peaked in 2009 and was lower in 2010, with an estimated level of 269 per 100 000 live births, which is still above the target set for the NSDA.

There is still a need to develop a methodology to provide estimates of sub-national trends for the provinces and health districts.

KEY MORTALITY INDICATORS, RMS 2009-2012[1]

LIFE EXPECTANCY AND ADULT MORTALITY (OUTPUT 1)					
INDICATOR	**TARGET 2014**	**2009**	**2010**	**2011**	**2012**
Life expectancy at birth Total	59.1 (Increase of 2 years)	57.1	58.5	60.5	61.3
Life expectancy at birth Male	56.6 (Increase of 2 years)	54.6	56.0	57.7	58.5
Life expectancy at birth Female	61.7 (Increase of 2 years)	59.7	61.2	63.3	64.0
Adult mortality ($_{45}q_{15}$) Total	43% (10% reduction)	46%	43%	40%	38%
Adult mortality ($_{45}q_{15}$) Male	48% (10% reduction)	51%	48%	46%	44%
Adult mortality ($_{45}q_{15}$) Female	37% (10% reduction)	40%	38%	35%	32%
MATERNAL AND CHILD MORTALITY (OUTPUT 2)					
INDICATOR	**TARGET 2014**	**2009**	**2010**	**2011**	**2012**
Under-5 mortality rate (U5MR) per 1 000 live births	50 (10% reduction)	56	52	40	41
Infant mortality rate (IMR) per 1 000 live births	35 (10% reduction)	39	35	28	27
Neonatal mortality rate[2] (<28 days) per 1 000 live births	12 (10% reduction)	14	14	13	12
INDICATOR	**TARGET 2014**	**2008[4]**	**2009**	**2010**	
Maternal mortality ratio[3] (MMR) per 100 000 live births	252 (reverse increasing trend and achieve 10% reduction)	280	304	269	

1. Numbers for 2009-2011 differ slightly from previous report because estimates of births and the population exposed to risk were updated to take into account the 2011 census results
2. DHIS data
3. Stats SA data
4. Baseline for MMR set at 2008 due to lag in availability of data

INTRODUCTION

This is the second in the series of annual reports utilising the data from the Rapid Mortality Surveillance (RMS) database described in the previous report (Bradshaw, Dorrington and Laubscher, 2012) to track several high-level indicators of mortality. These indicators include life expectancy, the adult mortality index ${}_{45}q_{15}$, under-5 mortality rate, infant mortality rate and the neonatal mortality rate. The report also includes an estimate of the maternal mortality ratio (MMR), which relies on the cause of death data reported by Stats SA. For this report, the RMS data series has been updated to the end of 2012 and the cause of death data to the end of 2010.

Since the release of the previous RMS report, the 2011 Census population estimates have been released (Stats SA, 2013a). These estimates are quite different in some respects (in particular the overall size of the population and the age distribution of the population below the age of 30, which in turn imply, inter alia, quite a different pattern of births over time than that assumed in the previous report) from what was expected on the basis of the various projection models. It was therefore decided that this new information about the population needed to be considered in estimating the mortality indicators by using mid-year population estimates, which were derived to be consistent with the 2011 Census population[1] (Dorrington, 2013). As a result, it was necessary to re-estimate the indicators for earlier years and targets so that they were consistent with those for 2012 (or 2010 in the case of the MMR), including values for the baseline year 2009 (2008 for MMR).

As was done previously, adjustments have been made to allow for the under-registration of deaths, after first adjusting the data to account for a proportion of people who are not on the National Population Register. In addition, the same methodology that was previously used, was used to estimate the MMR from the cause of death data.

DATA SOURCE

The Department of Home Affairs is responsible for civil registration and the maintenance of a computerised National Population Register (NPR). In the event of a death, a death notification form is submitted to the Department, which then issues a burial order and an abbreviated death certificate to the family of the deceased. For deaths of individuals who have a South African ID number or whose birth has been registered, the National Population Register is updated as part of the registration process.

Since 1999, the Medical Research Council has obtained monthly information about the deaths registered on the National Population Register and has developed a consolidated data base. Several steps in the data management process ensure that the confidentiality of the data is maintained. Ethics approval was obtained from the University of Cape Town.

These data are subject to two forms of under-reporting. The first is non-registration on the population register (because the deceased did not have a South African birth certificate or identity document). The second, common with deaths from the vital registration system (as reported in the cause-of-death data released by Stats SA), is non-registration of the death.

As the RMS data only identifies cause of death as natural or unnatural, one needs to rely on the cause-of-death data from Stats SA to identify the maternal deaths. The latest available data are for the year 2010 (Stats SA, 2013b). In addition, too few neonatal deaths are recorded in the RMS data, and since there is a two-year lag in the release of the cause-of-death data, we use data from the District Health Information System 2009-13 (DHIS) to estimate the number of neonatal deaths that occur in public hospitals to produce recent estimates.

POPULATION ESTIMATES

Demographic indicators require estimates of the population and births that should ideally:

- be available by single years of age to allow for more accurate estimation of the indicators
- not change frequently (to avoid having to recast the indicators)
- be as consistent with the age distribution of the population of the 2001 and 2011 Censuses and the 2007 Community Survey as is reasonable, allowing for possible undercounting of children and age exaggeration at old age, and so on.

Previously the estimates produced by the ASSA2008 AIDS and Demographic Model were used to calculate the mortality-related indicators in line with the recommendations of the Health Data Advisory and Coordination Committee of the Department of Health (HDACC, 2011). However, since then, the 2011 Census population estimates have been released and they suggest that not only has fertility been different from that assumed by projection models (including the ASSA model) for the past 10-15 years, but also that immigration has been somewhat higher than assumed by the projection models. Thus, for this report, it was necessary to use an alternative set of mid-year population estimates with an age distribution and size consistent with those of the 2001 and 2011 Censuses (Dorrington, 2013).

[1] The official mid-year estimates produced by Stats SA (2013d) have a markedly different age structure from that of the 2011 Census.

In addition, the numbers of births in the years 2000-2010 were estimated as the numbers at various ages back-projected to the year of birth. It can be seen that the number of births implied by the 2011 Census (ie consistent with the number of survivors counted in the 2011 Census) is somewhat different from that previously assumed from the ASSA2008 model (Figure 1).

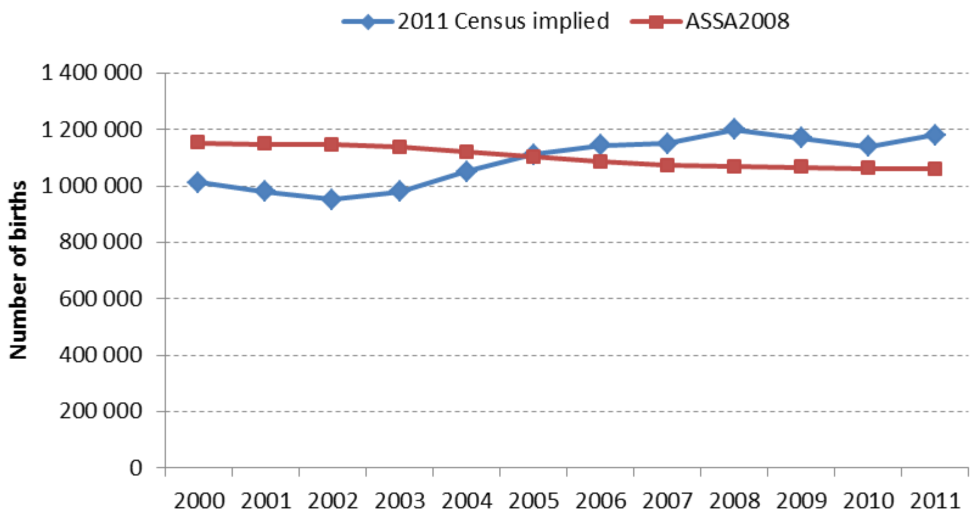

Figure 1: Comparison of South African births implied by the 2011 Census to those projected by the ASSA2008 model

For this report, the numbers of births for the years 2000-2010 were taken as those estimated by back-projecting the numbers surviving to the 2011 Census. The numbers of births in the years 2011 and 2012 were estimated to be 1.25 times the number of births recorded by the DHIS. (Comparison of the number of births recorded by the DHIS and those derived by back-projecting the 2011 Census population suggest that for the years 2004-2010, the DHIS captures, fairly consistently each year, some 80% of the total births estimated from the Census.)

ADJUSTMENTS

Evaluation of the RMS data indicates that there has been an improvement in birth and ID registration, and a consequent reduction in the under-recording of deaths in the population register relative to those captured by Stats SA's cause-of-death processing. From Figure 2 it can be seen that more than 95% of the death notifications of people aged 25 and over, and close to 90% of all other ages except those in the first year of life, are on the NPR. With the exception of those aged 15-19 years of age, the proportion of registered deaths on the population register has plateaued. The low proportion of death notifications under the age of one being registered on the population register is mainly because the deaths occurred before the births could be registered.

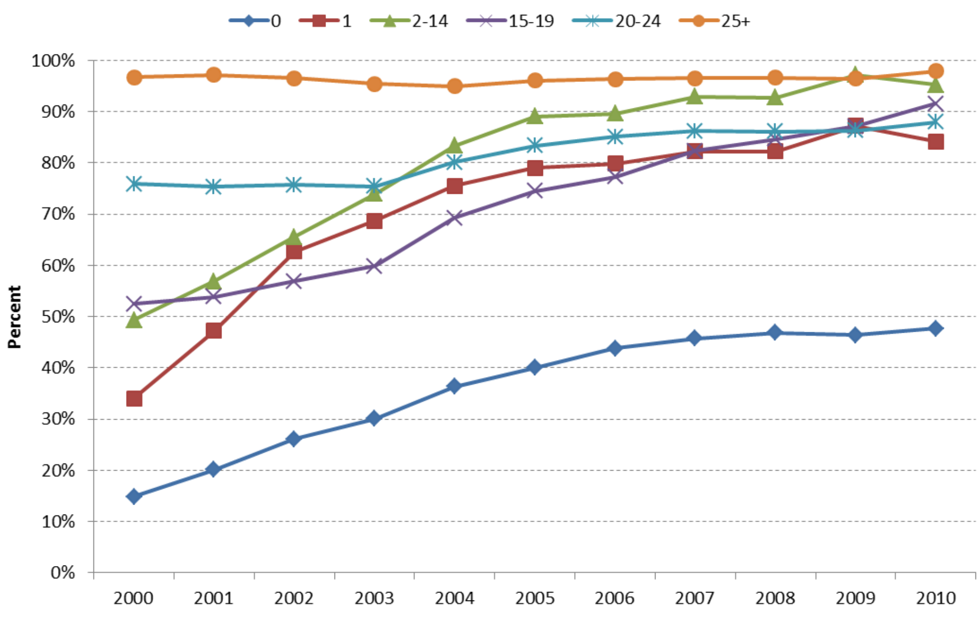

Figure 2: RMS deaths as a proportion of Stats SA deaths by age group, 2000-2010

As was done in the previous report, the RMS data are adjusted in two steps. The first step is to account for the fact that the population register does not include the total population. The second step is to account for under-registration of deaths. The first adjustment is made by single ages up to the age of 24 years and in three broad age groups: 25-59, 60-89 and 90+ years for each sex, to approximate Stats SA vital registration (VR) data for each year from 2006 up to 2010. The same factors are then used to produce estimates for 2011 and 2012, for which cause of death data have yet to be processed.
Thereafter, the estimated numbers of deaths are adjusted for general under-registration (i.e. deaths with no death certificates). The levels of completeness of the VR data assumed are as follows:

age 0: 85.0%
age 1: 53.8%
ages 2–14: linear trend between the figure for age 1 and figure of 93% for age 15
ages 15+: 93.0%

The estimates of completeness of reporting deaths under the age of 15 are lower, markedly so for the youngest ages, than those from last year. The reason for this is that the numbers of births in recent years (as implied by the 2011 Census) are some 10-15% higher than previously estimated. A brief description of the approach used to estimate the completeness of reporting deaths is given in the appendix.

Aside from adjusting the cause of death data for under-registration of deaths and the high proportion of ill-defined causes, according to the practice of the UN advisory group on Maternal Mortality (MMIEG), the number of deaths should be increased by 50% to allow for the general under-notification of maternal causes. This practice is based on the experience of some 22 studies estimating the extent in under-notification in countries with good VR data (WHO, 2010).

The RMS data cannot be used to estimate neonatal deaths, because less than 10% of the registered deaths in this age group are captured on the NPR, possibly because the birth is not registered. Furthermore, this proportion appears to have been increasing (possibly with improving birth registration), which makes it difficult to extrapolate. Comparison of the number of neonatal deaths recorded in the DHIS with those in the VR suggests that the DHIS represents more than three-quarters of the deaths in the VR. In order to track neonatal mortality in parallel with the infant and under-5 mortality, the number of neonatal deaths that occurred in facilities and were captured by the DHIS is scaled up to estimate the number expected to be captured by the VR data. This result is then corrected for the same level of under-registration as is applied to infant deaths, in much the same way as the infant and under-5 deaths are estimated. For the years for which VR data are not yet available, the completeness of the neonatal deaths in the DHIS is estimated as the completeness for the previous year plus any increase in the ratio of neonatal deaths to stillbirths over the previous year. The rationale for this is that one would expect the ratio of neonatal deaths to stillbirths to remain fairly constant over time, so any increase in this ratio over time is probably due to an increase in completeness of coverage.

Thus for year t, if VR(t) is the number of neonatal deaths from vital registration and NND(t) is the number of neonatal deaths from DHIS, and SB(t) is the number of stillbirths from the DHIS then the coverage of DHIS to VR in year t was calculated as

$c(t) = NND(t-1)/VR(t-1)$ if $VR(t-1)$ is available, otherwise
$c(t) = c(t-1) + NND(t)/SB(t) – NND(t-1)/SB(t-1)$.

TRENDS IN RMS DATA

The number of deaths from the National Population Register is shown in Table 1 for 2000-2012 alongside the number of deaths from the Stats SA cause-of-death reports for 2000-2010. The total numbers (T) are broken down into natural deaths (N) and unnatural deaths (U). It can be seen that the total number of deaths in both series increased to a peak in 2006. The Stats SA numbers increased from 416 420 in 2000 to a peak of 613 108 in 2006 and declined to 543 856 in 2010. The RMS numbers increased from 359 470 in 2000 to a peak of 555 081 in 2006 and declined to 466 653 in 2012. It should be noted that the changes in the numbers of deaths cannot be interpreted without taking into account the improvement in death registration, and in the case of the RMS, improved birth registration, over the period.

The rapid decline in the number of deaths makes it important to investigate whether there are any indications of system failure. Although subtle changes in completeness of recording are quite difficult to detect, extensive investigation did not identify any evidence of systems failure.

Table 1: Number of natural (N), unnatural (U) and total (T) deaths in RMS compared with Stats SA data by year

	RAPID MORTALITY SURVEILLANCE			STATS SA CAUSE-OF-DEATH DATA		
YEAR	Natural (N)	Unnatural (U)	Total (T)	Natural (N)	Unnatural (U)	Total (T)
2000	319 228	40 242	359 470	366 633	49 787	416 420
2001	360 348	39 835	400 183	404 775	50 351	455 126
2002	401 098	41 563	442 661	450 851	51 486	502 337
2003	446 580	42 204	488 784	504 148	52 850	556 998
2004	467 889	41 928	509 817	523 676	53 366	577 042
2005	492 688	43 645	536 333	544 344	53 977	598 321
2006	509 636	45 445	555 081	559 873	53 235	613 108
2007	505 367	46 606	551 973	549 875	54 496	604 371
2008	498 699	46 771	545 470	542 274	53 350	595 624
2009	488 305	44 860	533 165	529 428	50 283	579 711
2010	465 363	43 597	508 960	495 479	48 377	543 856
2011	442 291	42 732	485 023	-	-	-
2012	423 129	43 524	466 653	-	-	-

The trends in the number of deaths from the RMS are shown in Figure 3 and indicate a marked decline since 2006 in natural causes in the young adult age group. This decline is mirrored for children <15 years with the exception of the most recent year.

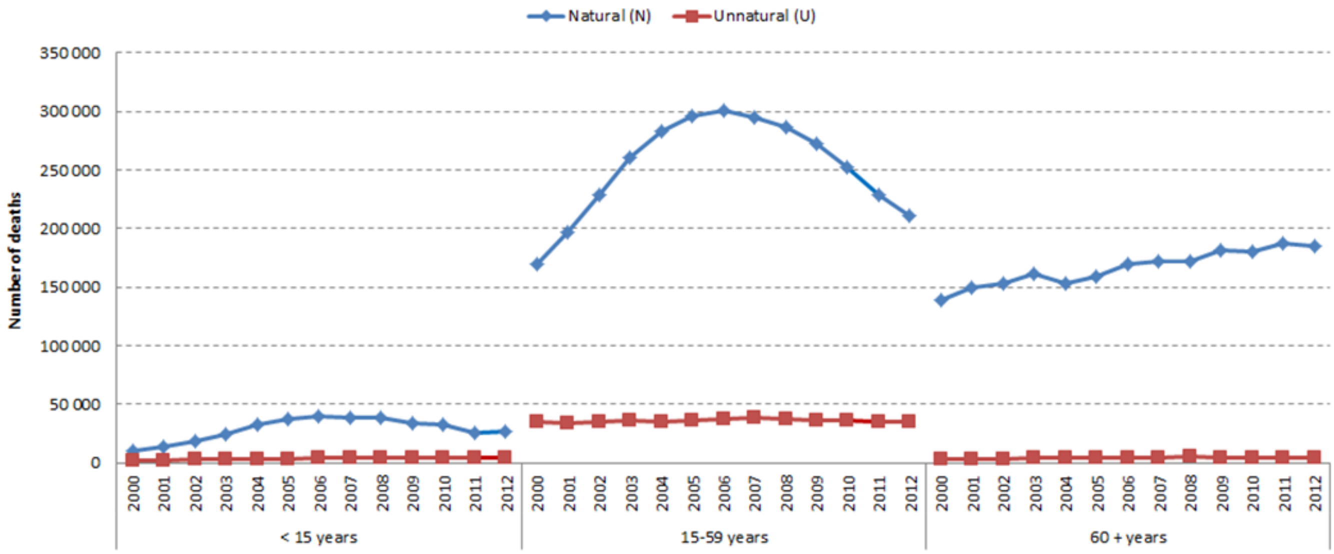

Figure 3: Trend in the number of natural (N), unnatural (U) by broad age group, RMS 2000-2012

The proportion of the VR deaths captured by the RMS increased from 86.3% in 2000 to 93.6% in 2010 (Figure 4). The proportion of unnatural deaths captured by the RMS was at a constant level of approximately 80% until 2004, after which it increased to above 90% for 2009 and 2010.

Table 2 shows the numbers in broad age groups, and the proportion of the VR deaths captured by the RMS is shown in Figure 5 for each age group. There has been a considerable increase in the proportion for children <15 years, with the proportion of unnatural deaths in the RMS being higher than that of the natural deaths. The reason for this is probably that most of the deaths at the early ages were due to unnatural causes, and it is at these ages that death is most likely to occur before the birth has been registered (resulting in the death not being captured on the population register). There has been less change in the 15-59 year age group, while the proportions in the 60+ year age group have been consistently high for natural deaths and in the case of unnatural deaths have increased since 2005, appearing to plateau at around 75% in the last few years.

Table 2: Number of natural (N), unnatural (U) and total (T) deaths in RMS in broad age groups compared with Stats SA data by year

	RAPID MORTALITY SURVEILLANCE			STATS SA CAUSE OF DEATH DATA		
YEAR	Natural (N)	Unnatural (U)	Total (T)	Natural (N)	Unnatural (U)	Total (T)
	<15 years					
2000	9 682	2 075	11 757	41 548	4 615	46 163
2001	13 378	2 283	15 661	43 534	4 712	48 246
2002	18 995	2 617	21 612	50 006	4 376	54 382
2003	24 439	2 873	27 312	55 995	4 715	60 710
2004	32 401	3 232	35 633	62 263	5 120	67 383
2005	37 031	3 498	40 529	67 593	5 078	72 671
2006	39 168	3 815	42 983	68 856	5 394	74 250
2007	38 859	3 973	42 832	65 924	5 316	71 240
2008	39 058	3 875	42 933	65 288	4 964	70 252
2009	33 833	4 022	37 855	55 679	4 800	60 479
2010	32 341	3 904	36 245	51 669	4 777	56 446
2011	25 374	3 853	29 227	-	-	-
2012	26 687	4 103	30 790	-	-	-
	15-59 years					
2000	170 044	34 532	204 576	185 872	39 611	225 483
2001	197 284	34 089	231 373	213 129	40 262	253 391
2002	228 815	35 302	264 117	247 697	41 442	289 139
2003	260 984	35 652	296 636	284 618	42 164	326 782
2004	282 753	34 944	317 697	304 713	41 816	346 529
2005	296 196	36 393	332 589	314 932	42 720	357 652
2006	301 284	37 811	339 095	320 223	42 376	362 599
2007	294 608	38 615	333 223	311 530	43 206	354 736
2008	287 152	37 832	324 984	303 474	42 481	345 955
2009	272 906	36 724	309 630	290 139	39 684	329 823
2010	252 244	35 615	287 859	265 233	38 011	303 244
2011	228 128	34 743	262 871	-	-	-
2012	211 243	35 272	246 515	-	-	-
	60+ years					
2000	139 502	3 635	143 137	139 213	5 561	144 774
2001	149 686	3 463	153 149	148 112	5 377	153 489
2002	153 288	3 644	156 932	153 148	5 668	158 816
2003	161 157	3 679	164 836	163 535	5 971	169 506
2004	152 735	3 752	156 487	156 700	6 430	163 130
2005	159 461	3 754	163 215	161 819	6 179	167 998
2006	169 184	3 819	173 003	170 794	5 465	176 259
2007	171 900	4 018	175 918	172 421	5 974	178 395
2008	172 489	5 064	177 553	173 512	5 905	179 417
2009	181 566	4 114	185 680	183 610	5 799	189 409
2010	180 778	4 078	184 856	178 577	5 589	184 166
2011	188 789	4 136	192 925	-	-	-
2012	185 199	4 149	189 348	-	-	-

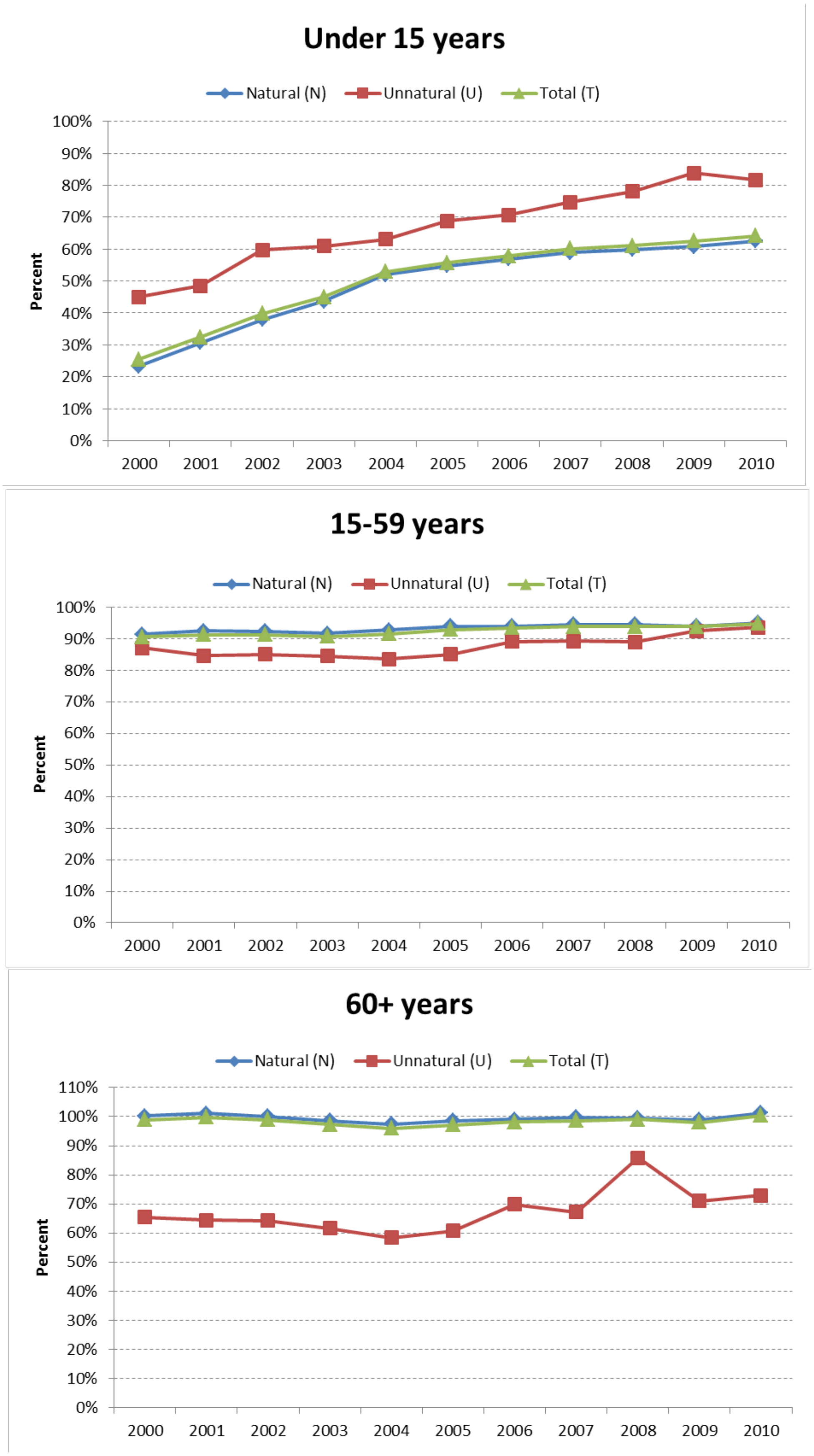

Figure 4: Ratio of RMS to Stats SA data (%) in broad age groups by natural (N), unnatural (U) and total (T) category, 2000-2010

CORRECTING FOR INCOMPLETENESS

Figure 6 to Figure 11 compare the number of deaths, in total and for various age ranges, as reported by Stats SA (VR), from the National Population Register (RMS), together with the VR adjusted for incompleteness of registration (Adj VR), the RMS adjusted for registered deaths of people not on the National Population Register (Est VR) and this number further adjusted for incompleteness of registration (Est Adj VR).

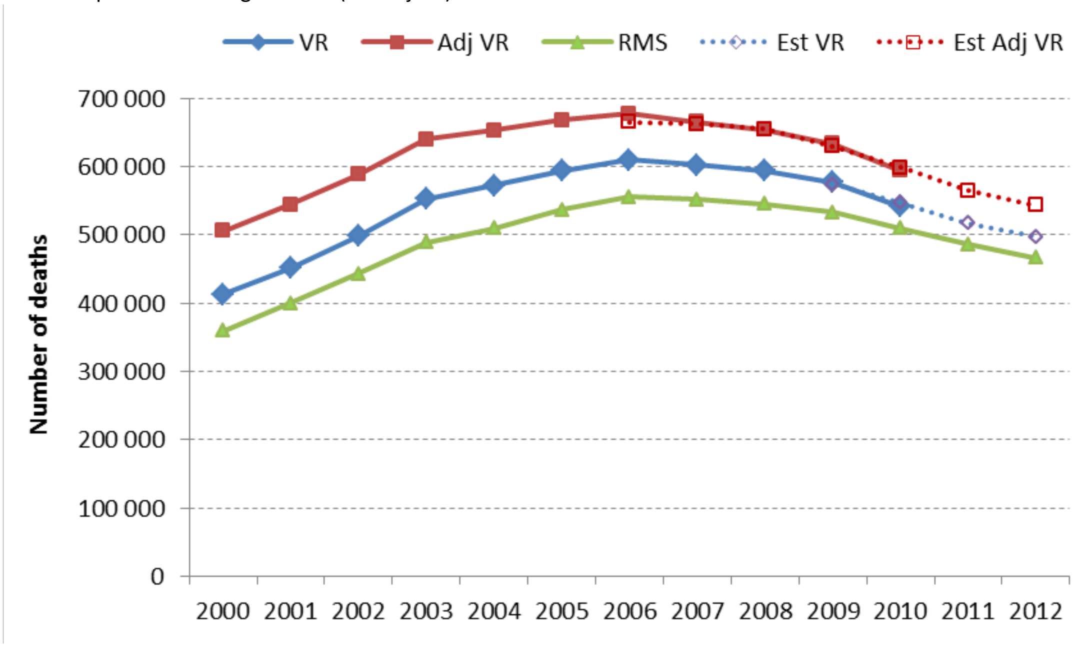

Figure 5: VR, VR adjusted for incompleteness of reporting, RMS, estimated VR, estimated adjusted VR: Total deaths

In total (Figure 6), and for ages 15-59 (Figure 10), the adjustments to the RMS data appear to work very well. However, there were slight differences for the period 2006-2008 in the other age ranges.

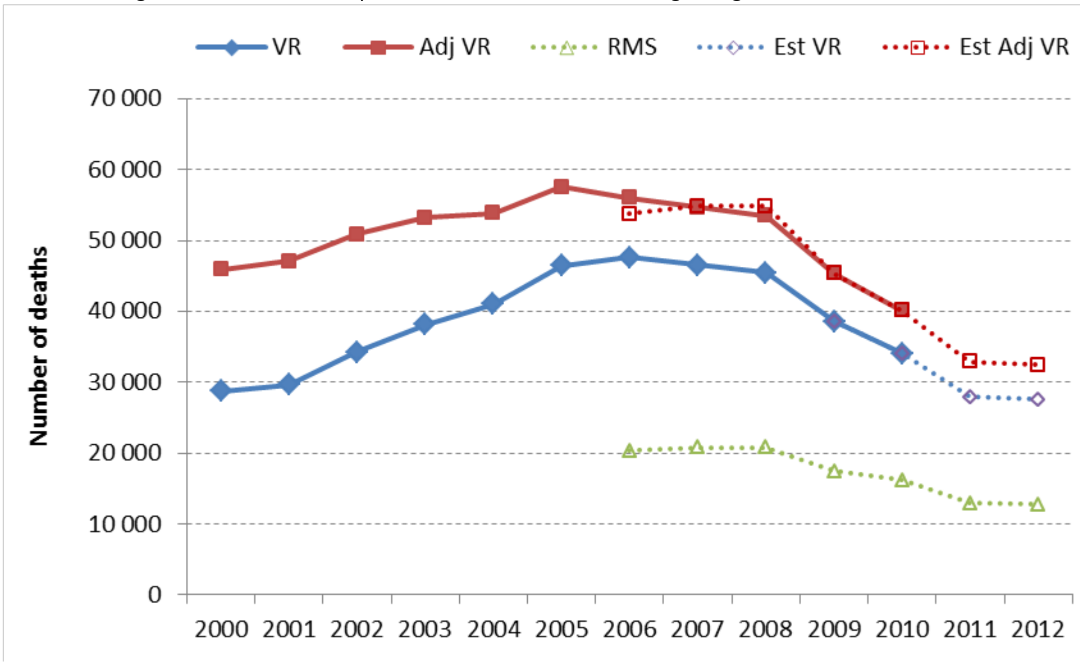

Figure 6: VR, VR adjusted for incompleteness of reporting, RMS, estimated VR, estimated adjusted VR: Deaths < 1

The comparison of the number of deaths under the age of 1 year (Figure 7) indicate the large (but declining over time) adjustment required for deaths of babies not on the NPR. However, despite the uncertainty introduced by having to make such a large adjustment, the estimates produced from the RMS appear quite reasonable. The slight discrepancy for 2006-2008 is the result of small errors in the projection of the ratio of RMS to VR in the early years of the process (VR data up to 2004).

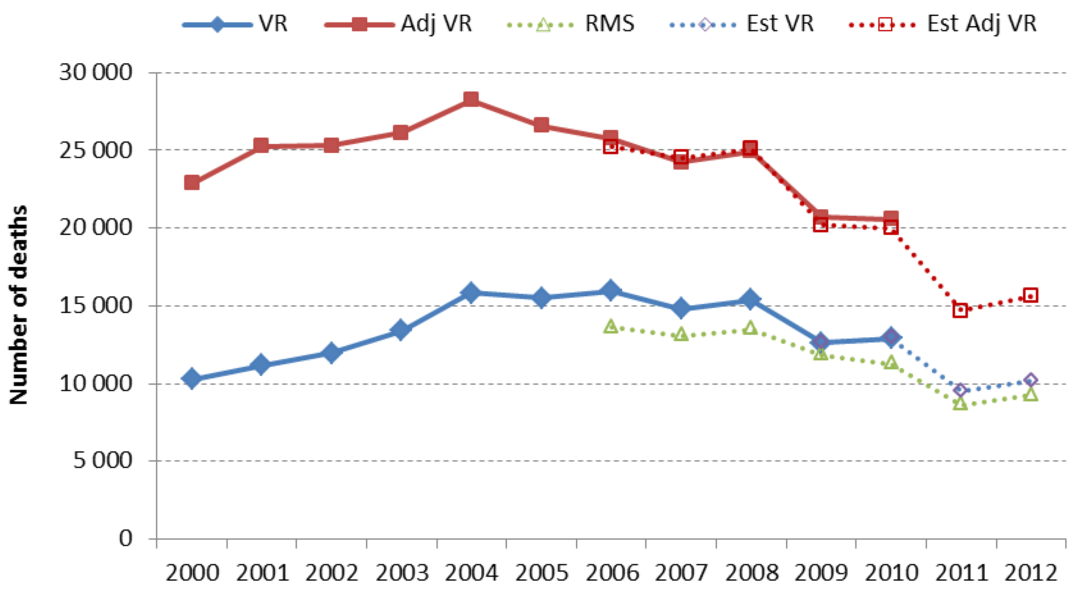

Figure 7: VR, VR adjusted for incompleteness of reporting, RMS, estimated VR, estimated adjusted VR: Deaths 1-4

The adjustment required to account for deaths of children under the age of 15, particularly those under the age of one, produces estimates that are slightly out for the years 2006-2008 (Figure 7 to Figure 9). However, after this period, the estimates appear to be very consistent.

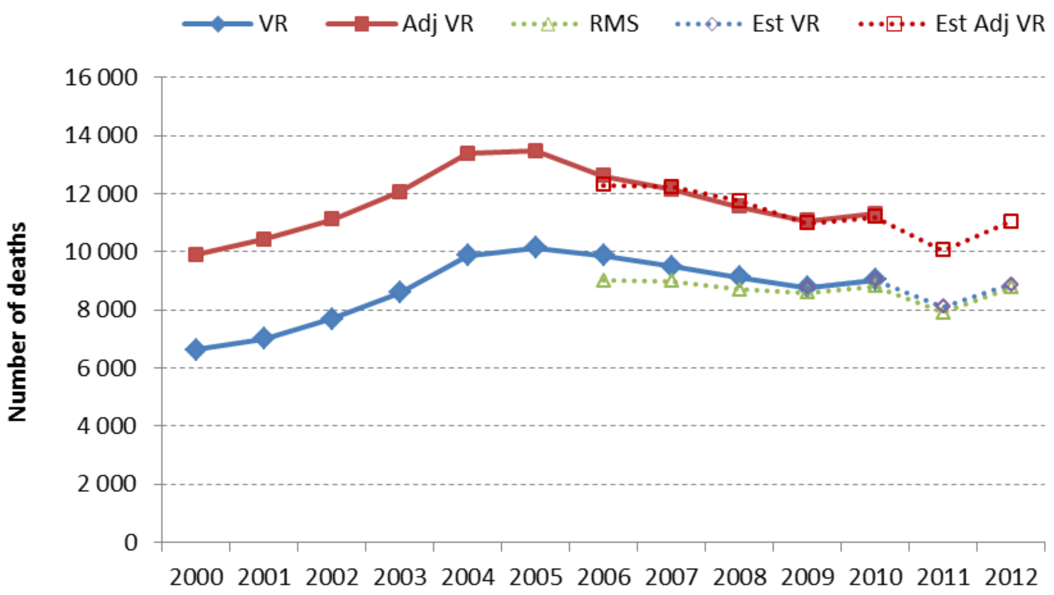

Figure 8: VR, VR adjusted for incompleteness of reporting, RMS, estimated VR, estimated adjusted VR: Deaths 5-14

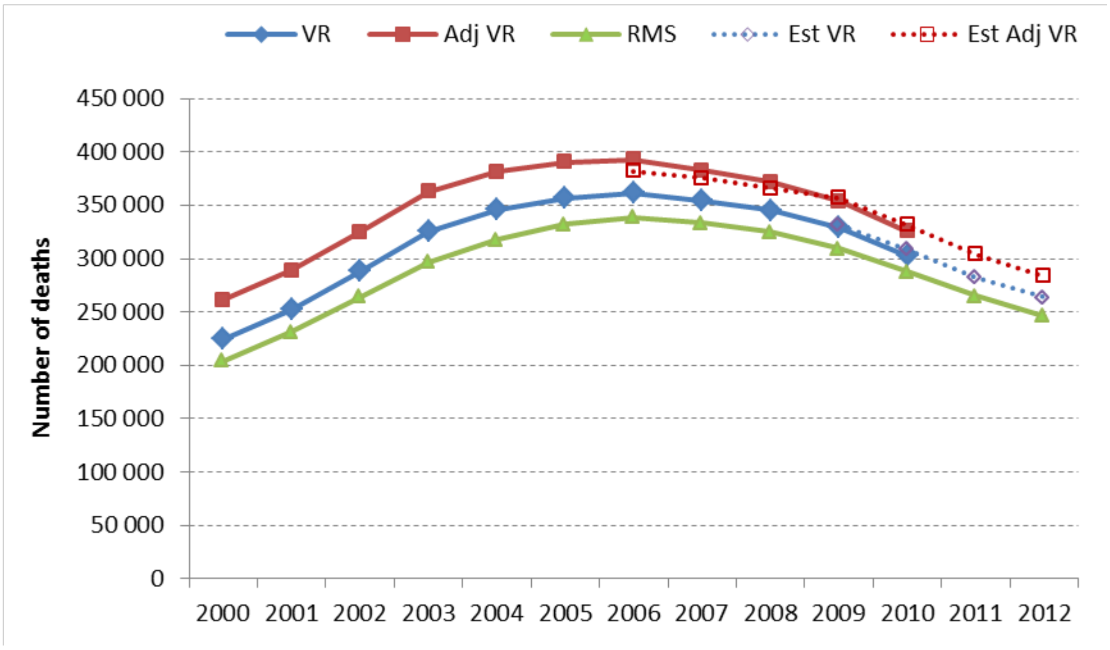

Figure 9: VR, VR adjusted for incompleteness of reporting, RMS, estimated VR, estimated adjusted VR: Deaths 15-59

From the comparisons shown in Figure 11, it appears as if the number of deaths captured in the RMS is virtually the same as those ultimately reported by Stats SA, suggesting that virtually everyone from the age of 60 is on the NPR.

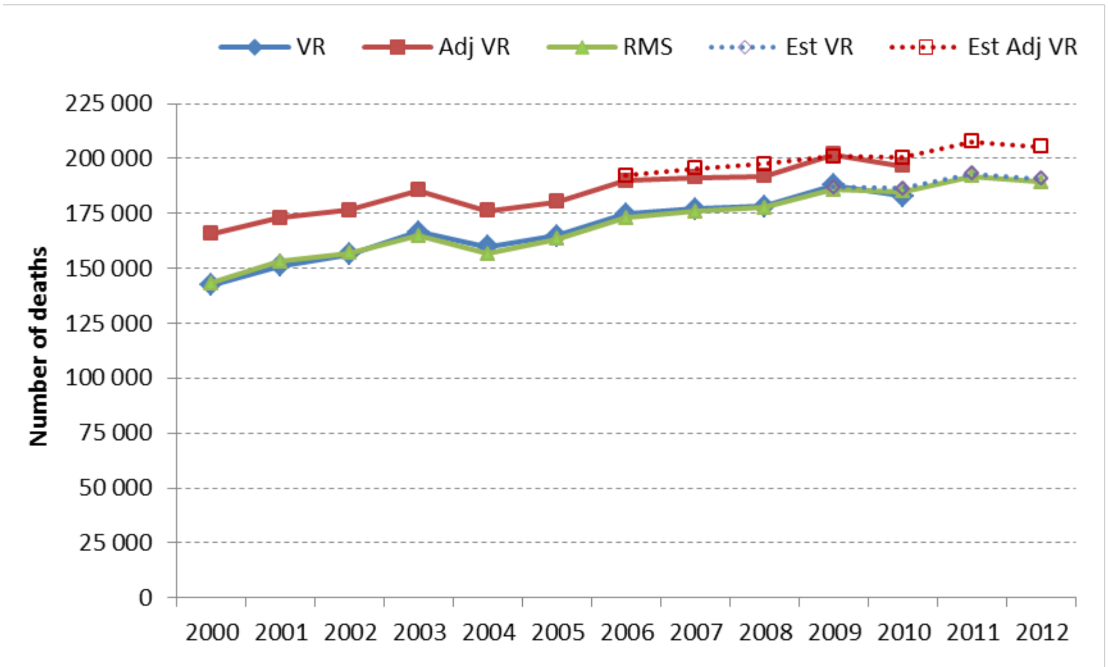

Figure 10: VR, VR adjusted for incompleteness of reporting, RMS, estimated VR, estimated adjusted VR: Deaths 60+

LIFE EXPECTANCY AND ADULT MORTALITY

Key indicators are estimated from mortality rates calculated from the adjusted number of deaths divided by the population estimate at each age. The life expectancy at birth as well as the adult mortality index, ${}_{45}q_{15}$, representing the probability of a 15-year-old person dying prematurely before the age of 60 years, are shown in Table 3. They are shown against targets recommended by the HDACC (HDACC 2011) reworked to be consistent with the new base estimates in 2008/9. It can be seen from the table that within three years, the life-expectancy targets have, somewhat unexpectedly, already been exceeded with particularly good progress between 2010 and 2011. This is mainly due to a significant decline in the mortality of those under the age of 1, but is also due to a decline in adult mortality, probably as a result of greater than expected roll-out of ARVs. The trends in these indicators since 2000 are shown in Figures 12 and 13. In addition, the trend in older-age mortality is tracked using the index e_{60} (the average life expectancy for people who have survived to age 60), and is shown in Figure 14. As can be seen from Figure 14, the mortality of older adults appears not to have changed greatly since 2001. The average life expectancy at the age of 60 is about 15 years for men and 19 years for women.

Table 3: Estimated life expectancy and adult mortality (${}_{45}q_{15}$), RMS 2009-2012

INDICATOR	TARGET 2014	2009	2010	2011	2012
Life expectancy at birth Total	59.1 (Increase of 2 years)	57.1	58.5	60.5	61.3
Life expectancy at birth Male	56.6 (Increase of 2 years)	54.6	56.0	57.7	58.5
Life expectancy at birth Female	61.7 (Increase of 2 years)	59.7	61.2	63.3	64.0
Adult mortality (${}_{45}q_{15}$) Total	43% (10% reduction)	46%	43%	40%	38%
Adult mortality (${}_{45}q_{15}$) Male	48% (10% reduction)	51%	48%	46%	44%
Adult mortality (${}_{45}q_{15}$) Female	37% (10% reduction)	40%	38%	35%	32%

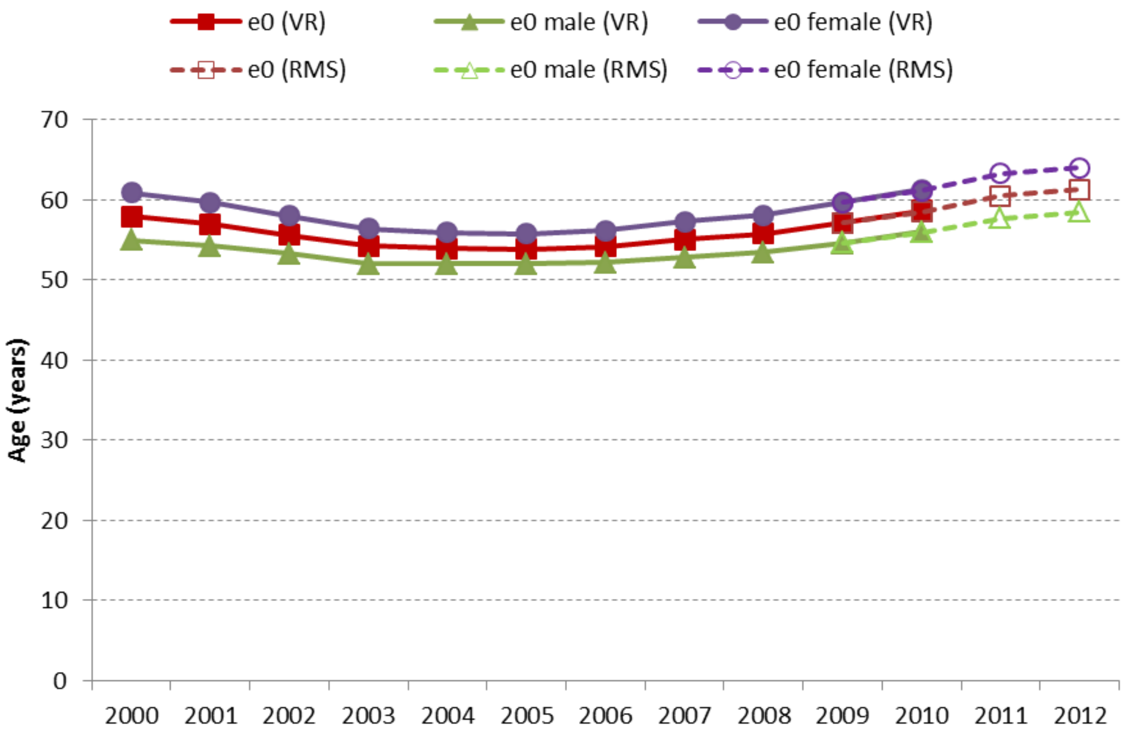

Figure 11: Life expectancy (e_0) from VR and RMS, 2000-2012 (after adjusting for incompleteness)

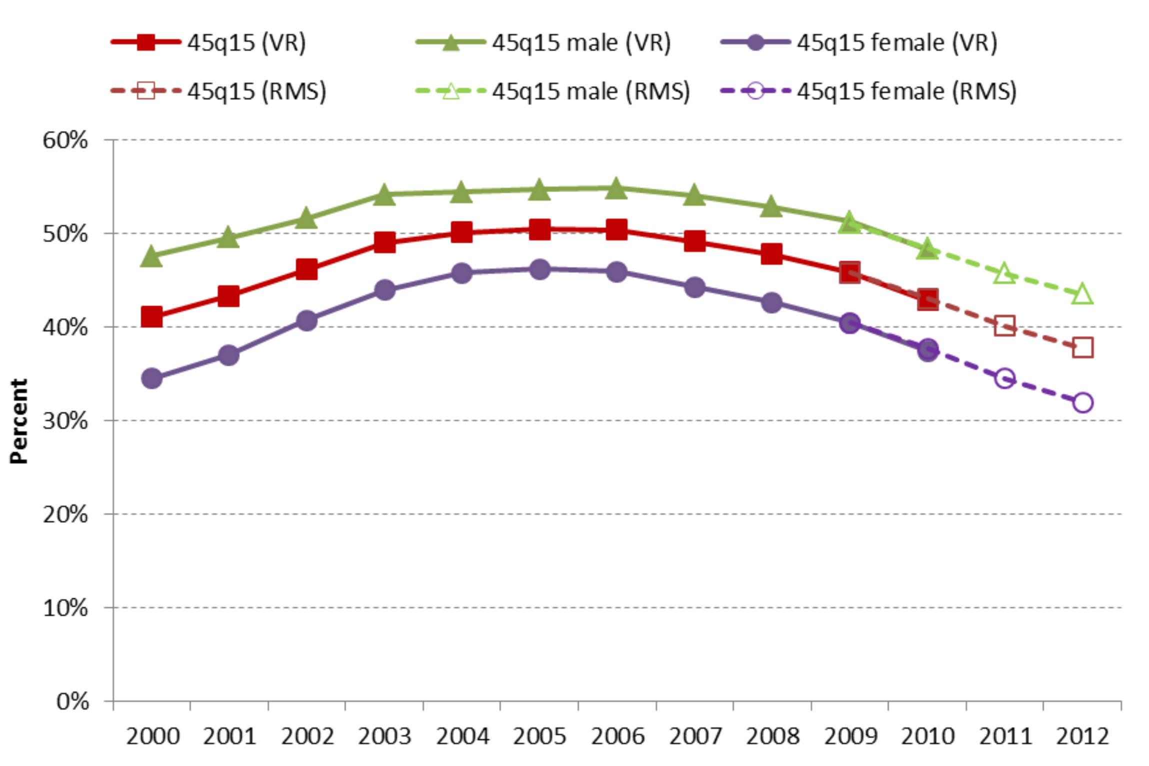

Figure 12: Adult mortality ($_{45}q_{15}$) from VR and RMS, 2000-2012 (after adjusting for incompleteness)

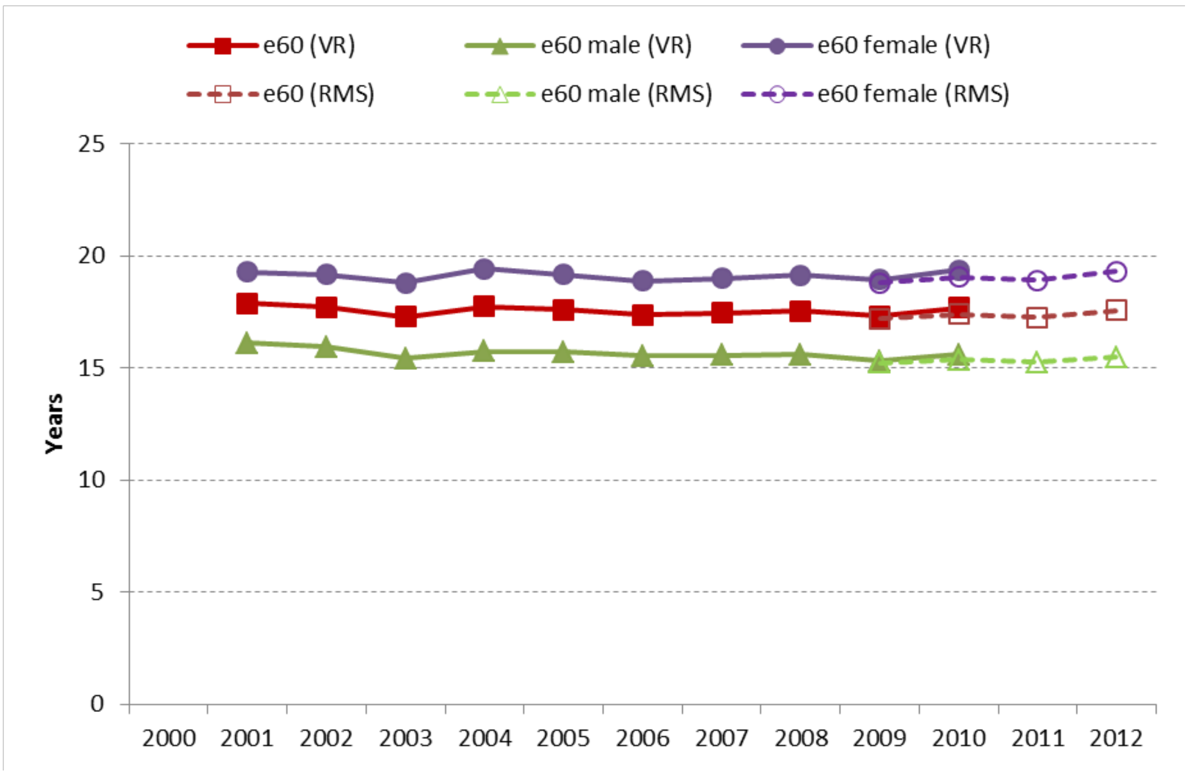

Figure 13: Life expectancy at the age of 60 (e_{60}) from VR and RMS, 2000-2012 (after adjusting for incompleteness)

CHILD MORTALITY (U5MR, IMR, NMR)

The annual number of deaths under 5 years of age in the RMS has declined from 34 006 in 2006 to 22 032 in 2012. The number of deaths by month, compared with the number of deaths reported by Stats SA, is shown in Figure 15. It can be seen that there is a high degree of correspondence between the two series, with a marked seasonal effect that has become more attenuated as the numbers decline. The seasonal effect is complex, with a summer peak early in the year followed by a peak in May/June.

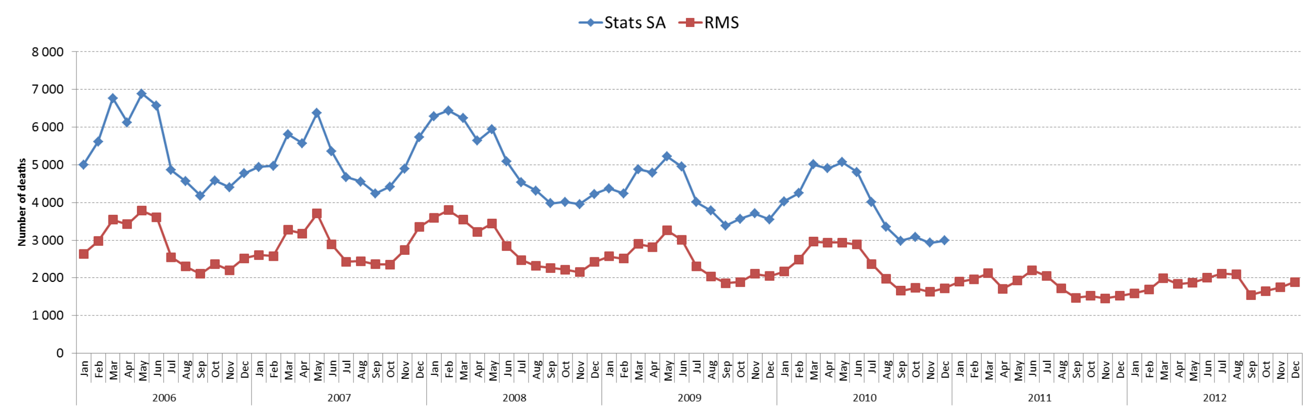

Figure 14: Monthly number of child deaths under 5 years from Stats SA and RMS, 2006-2012

The trends in selected causes in the Stats SA data for 2006-2010 are shown in Figure 15 It remains a challenge to know what contribution the reductions in HIV infection, the introduction of new vaccines, and improved access to water and sanitation have made to the decrease. However, generally, as the U5MR decreases, perinatal conditions contribute a higher proportion of the deaths.

Although the peaks are much lower in the later years, both diarrhoeal deaths (ICD code A09) and pneumonia deaths (ICD code J18) show characteristic seasonal patterns. In 2010, the diarrhoeal deaths peaked in March and the pneumonia deaths in April-June. The overall effect was a unimodal peak from March-June. The deaths from causes originating in the perinatal period (ICD codes P00-P99) do not follow any seasonal trend, while the deaths without any cause (ICD code R99) tend to follow the pneumonia pattern with a winter peak. The HIV deaths (ICD codes B20-B24), including pseudonyms (ICD codes B33 and D84), are much lower than expected, reflecting the tendency of not disclosing HIV on death notifications. The trend in the HIV deaths indicates a very mild seasonal effect. Deaths from diarrhoeal diseases showed considerable decline between 2008 and 2009, with a substantial drop in the summer peak and a smaller drop in the May peak. It remains a challenge to know what contribution the reductions in HIV infection, the introduction of new vaccines, and improved access to water and sanitation have made to the decrease. However, generally, as the U5MR decreases, perinatal conditions contribute a higher proportion of the deaths.

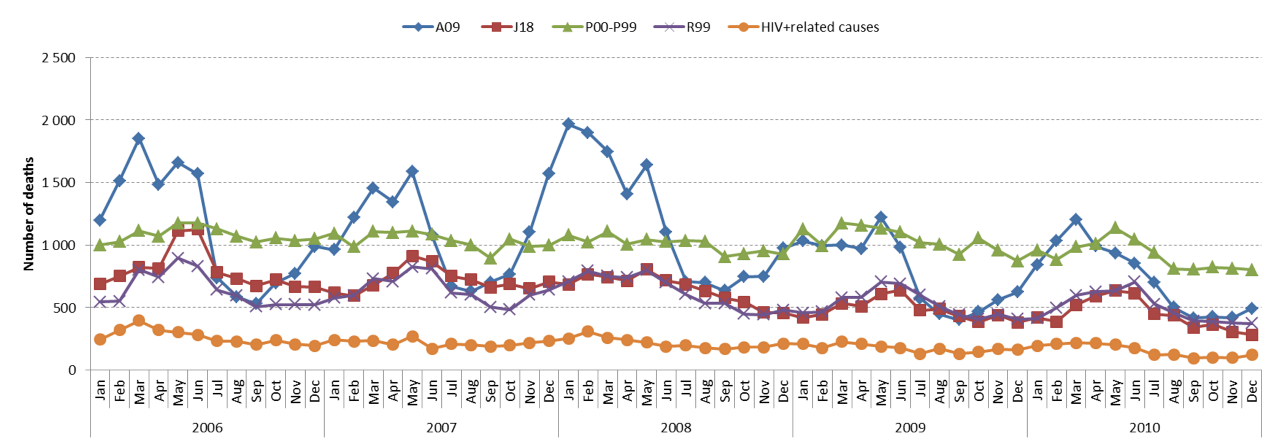

Figure 15: Number of child deaths under 5 years of age by selected cause of death, Stats SA 2006-2010

Figure 17 shows the monthly number of deaths from the RMS by year (with the lines becoming darker as the years progress), indicating the continued decline in the number of deaths under 5 years accompanied by an attenuation of the seasonal effect particularly between 2010 and 2011. The numbers for 2012 are at a similar level to those of 2011, indicating stagnation in the trend of the decline in child mortality that was observed between 2006 and 2011.

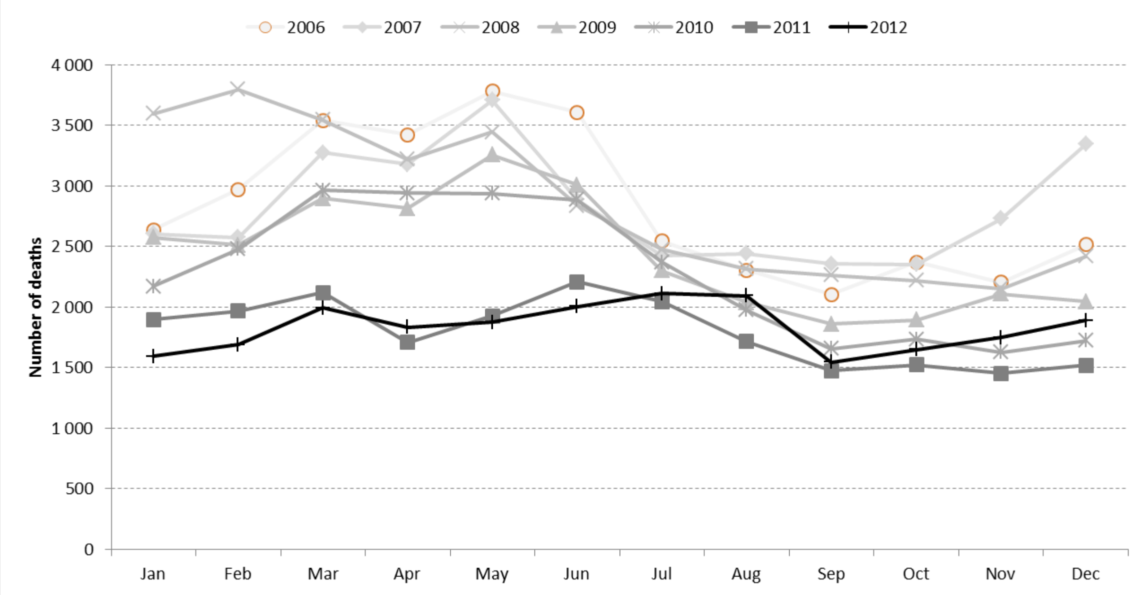

Figure 16: Number of child deaths under 5 years by month, RMS 2006-2012

When compared with the vital registration data from Stats SA, it is found that neonatal deaths in the RMS account for only 10% of the registered deaths. For this reason, it is necessary to consider an alternative data source to monitor the level of NMR. Figure 18 shows the number of neonatal deaths and stillbirths from the DHIS compared to the number of neonatal deaths from the cause-of-death data from vital registration. It can be seen that the neonatal deaths in the VR data were fairly steady from 2006-2009 and then dropped in 2010, largely in parallel to the decline observed in the number of stillbirths recorded by the DHIS. The number of neonatal deaths in the DHIS has increased steadily from 2008-2012. The VR data for registered stillbirths also showed little change between 2006 and 2009 at a level of about 15 000. These trends suggest that the increase in neonatal deaths captured by the DHIS is probably mainly due to increasing coverage over the period, rather than an increase in neonatal mortality.

In 2008, the DHIS captured 72% of the VR neonatal deaths, 75% in 2009, and 86% in 2010. Since both this proportion and the number of neonatal deaths relative to the number of stillbirths captured by the DHIS increased over this period, it is probable that the increase in number of neonatal deaths from the DHIS is mainly due to an increase in coverage. To allow for this increase in coverage, the completeness of the DHIS relative to the VR neonatal deaths for 2010-2012 was estimated as the completeness for the previous year plus any increase in the ratio of neonatal deaths to stillbirths over the previous year from the DHIS data. As a check of the reasonableness of the method, the estimate for 2009 is 74% vs the true estimate of 75%, while that for 2010 was 79% vs the true estimate of 86%. Although the difference in 2010 is unsatisfactory, the resulting error in the estimate is less than 10%.

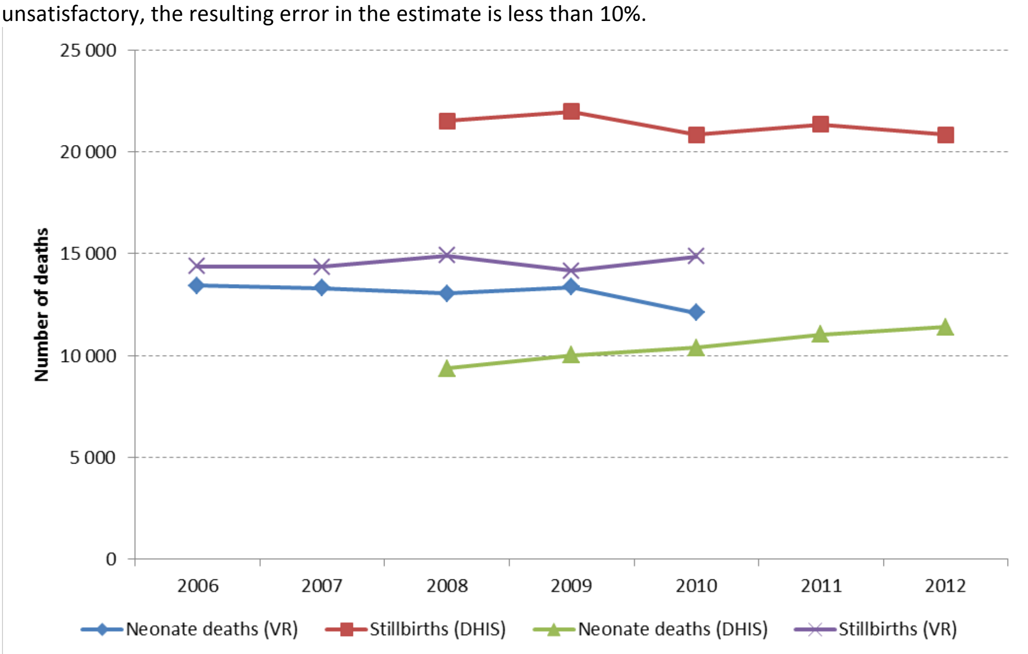

Figure 17: Stillbirths and neonatal deaths from VR and DHIS

Estimates of the key indicators of mortality for children are shown in Table 4 for the period 2009-2012, together with the reworked targets recommended by HDACC. Figure 19 shows the U5MR, the IMR and NMR. The U5MR and IMR are calculated from VR for the period 2006-2010 and from the RMS for the period 2010-2012, once the data have been adjusted for under-registration. The NMR is estimated from the registered deaths (adjusted for under-registration) for the period 2006-2010 and the DHIS (adjusted for under-coverage, relative to the registered deaths, and the incompleteness of the vital registration) for the period 2010-2012. From Figure 19, we can see that the estimates of the NMR derived from the DHIS are consistent with those derived later from the VR data, and that the NMR have remained between 12 (actually 12.46) and 14 per 1 000 live births for the period 2006-2012. In contrast, the IMR and the U5MR have declined rapidly since 2008, and by 2011 are well below the targets recommended by HDACC. However, the rapid decline appears to have ended, with no further decline in 2012. It is interesting to note that although there is no detail as to how the numbers were arrived at, the MDG Country Report 2013 (Stats SA 2013c) reported very similar values (IMR of 53 and U5MR of 38) for 2010.[2]

Table 4: Estimated U5MR, IMR and NMR, RMS 2009-2012 and DHIS 2009-2012

INDICATOR	TARGET 2014	2009	2010	2011	2012
Under-5 mortality rate (U5MR)	50 per 1 000 live births (10% reduction)	56 per 1 000 live births	52 per 1 000 live births	40 per 1 000 live births	41 per 1 000 live births
Infant mortality rate (IMR)	35 per 1 000 live births (10% reduction)	39 per 1 000 live births	35 per 1 000 live births	28 per 1 000 live births	27 per 1 000 live births
Neonatal mortality rate (<28 days) (NMR)	12 per 1 000 live births (10% reduction)	14 per 1 000 live births	14 per 1 000 live births	13 per 1 000 live births	12 per 1 000 live births

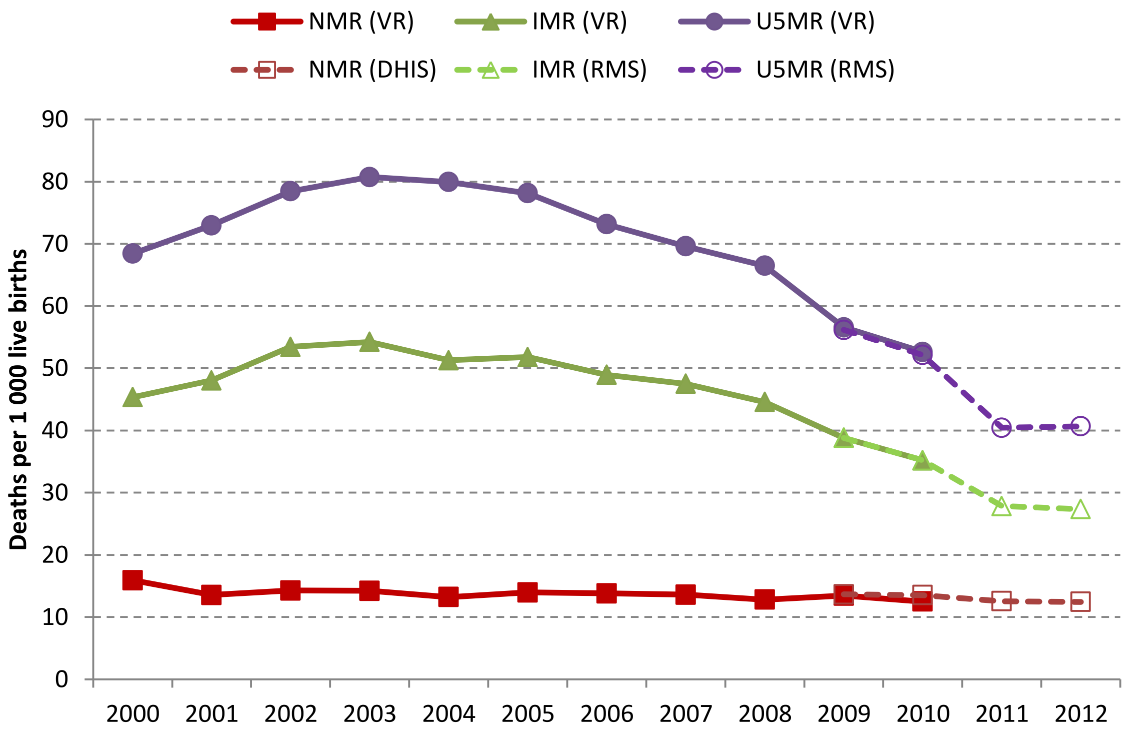

Figure 18: Under-5 mortality rate (U5MR) and infant mortality rate (IMR) from VR/RMS and neonatal mortality rate (NMR) from VR/DHIS

[2] The estimates (IMR of 67 and U5MR of 48) for 2007 are also broadly consistent with ours.

MATERNAL DEATH

The uncertainty about the level of maternal mortality is well recognised (HDACC, 2011; Bradshaw and Dorrington, 2012; Stats SA, 2013a). The estimates of the MMR based on the method proposed by HDACC are different from those published last year because of the change in the estimate of the number of births. Thus, now it is estimated that the MMR rose from 280 per 100 000 live births in 2008 to peak at 304 per 100 000 live births in 2009 before dropping to 269 per 100 000 live births in 2010 (Table 5). The new target adjusted to be consistent with the base estimate in 2008 suggests that the target has not yet been met. Despite using a different number of births (2.7% lower), the MDG Country Report 2013 (Stats SA 2013c) reported a very similar value (269 per 100 000 live births) for 2010.

Table 5: Estimated MMR, Stats SA 2008-2010

INDICATOR	TARGET 2014	2008	2009	2010
Maternal mortality ratio (MMR)	252 per 100 000 live births (Reverse increasing trend and achieve 10% reduction)	280 per 100 000 live births	304 per 100 000 live births	269 per 100 000 live births

Figure 20 shows the estimates for maternal mortality ratios (MMRs) and pregnancy-related mortality ratios (PRMRs) produced from different data sources. (The MMR includes direct and indirect maternal causes of death, while the PRMR also includes incidental deaths during the pregnancy risk period.) The values from vital registration and the confidential enquiry increase over the period, but provide values that are much lower than the estimates from surveys and the Census. Bradshaw and Dorrington (2012) argue that in the context of high adult mortality from AIDS, it can be assumed that there would be a high number of incidental deaths during the pregnancy-risk period that would be reflected in estimates from surveys and the Census, and may explain the high MMR of 625 for 2007 in the 2010 MDG Country Report (Stats SA, 2010). The HDACC estimates, as well as those reported in the 2013 MDG Country Report (Stats SA, 2013c), and the institutional MMR reported by the National Committee for Confidential Enquiry into Maternal Deaths (Pattinson, Fawcus and Moodley, 2013), indicate that maternal mortality may have peaked in 2009. The decline may primarily be the result of extensive provision of ARVs to pregnant women and the change in the ARV guideline to initiate HAART at a CD4 count of 350 cells/mm^3 (announced on 1 December 2009), as well as the move to use efavirenz instead of nevirapine when initiating women on HAART after the first trimester.

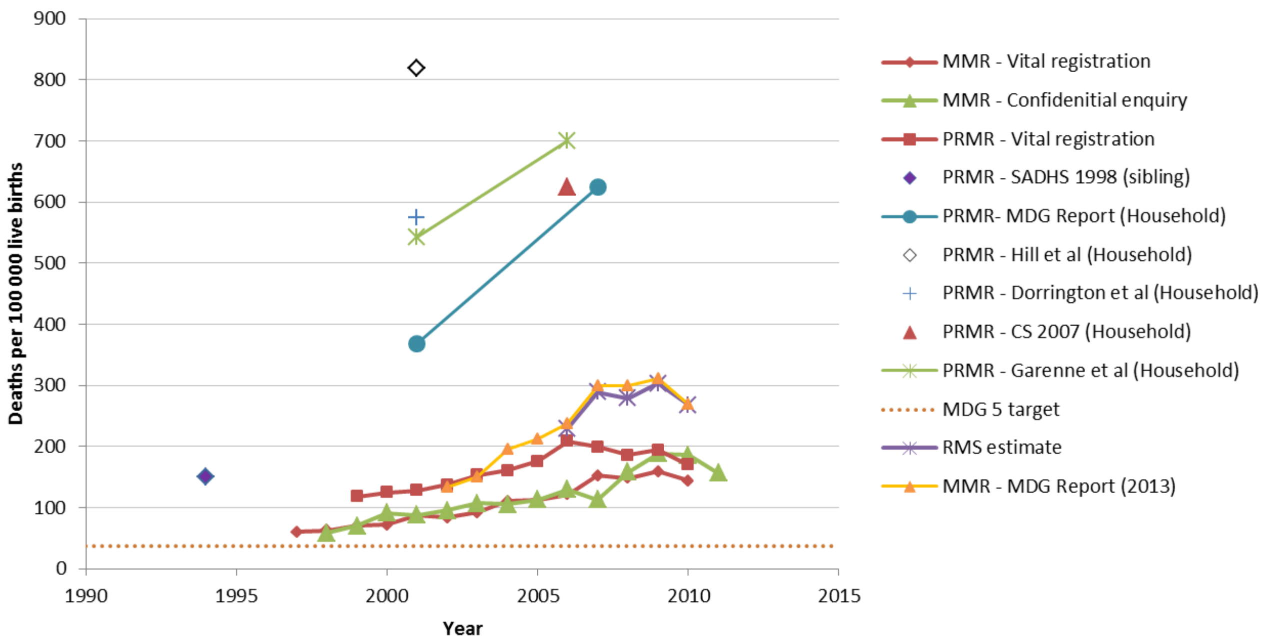

Figure 19: Estimate of MMR compared with other data sources
Source: Adapted and updated from Bradshaw and Dorrington, 2012

The numbers of registered deaths from maternal causes are shown in Figure 21, indicating a marked increase in the number of indirect maternal deaths since 2003. As noted by Bradshaw and Dorrington (2012), the timing of the increase in indirect maternal deaths is possibly surprising given that the rapid increase in the mortality of women aged 15-49 due to HIV started some 7-8 years ago and peaked some 2-3 years earlier. Longer exposures to HIV infection, adverse effects of antiretroviral therapy or changed death certification practice are possible reasons for the delayed increase, but this needs further investigation. However, what is of interest from Figure 21 is the fact that there appears to have been a drop in the number of deaths from every cause in 2010.

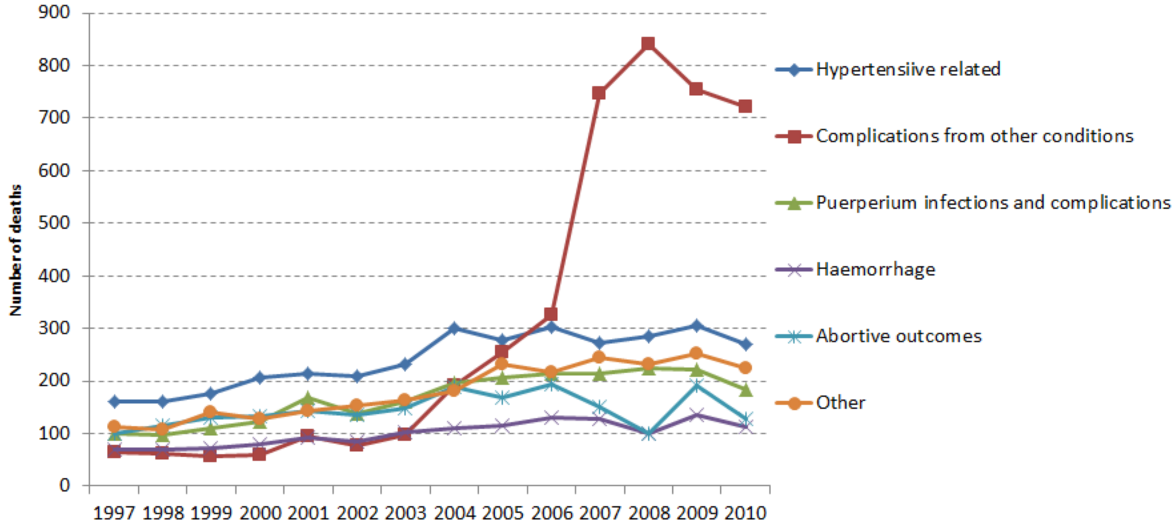

Figure 20: Trend in the number of maternal deaths by cause, Stats SA 1997-2010
Source: Updated from Bradshaw and Dorrington, 2012

COMPARISON WITH PREVIOUS ESTIMATES (IMPACT OF CENSUS 2011)

The use of alternative estimates of the population, and particularly numbers of births (together with a rework of the method for assessing the completeness of reporting of infant and child deaths) necessitated by the release of the 2011 Census estimates (Stats SA 2013a), produced estimates for past years that differ slightly from those published last year of the life expectancy at birth (Figure 22), the infant and child mortality (Figure 23), and, in particular, the maternal mortality ratio (Figure 24). There was very little difference for the other indicators.

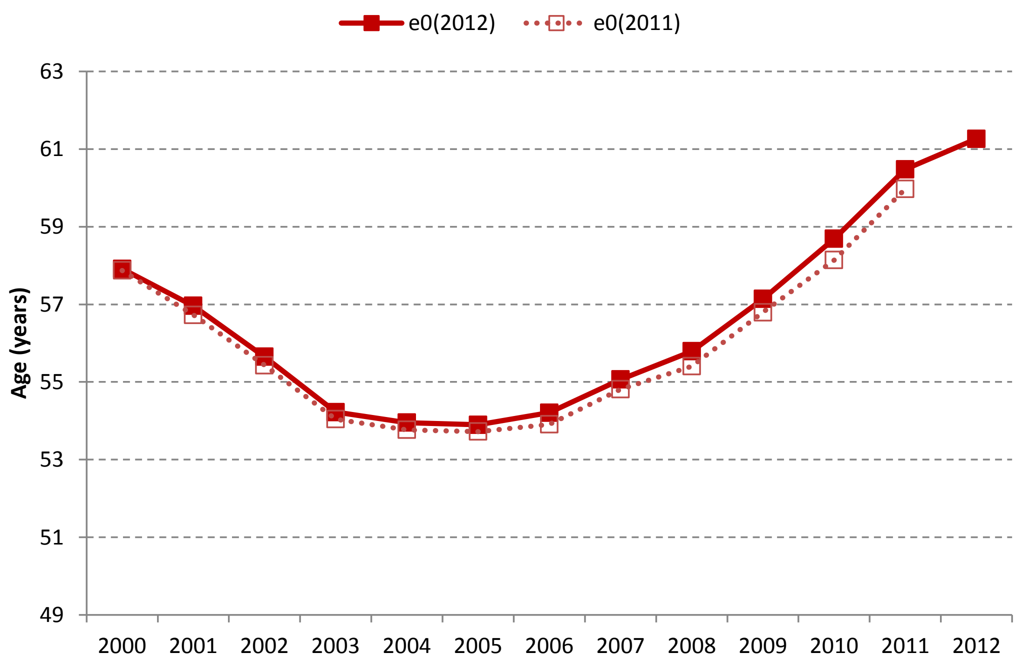

Figure 21: Comparison of estimates of life expectancy at birth (e0) with those from 2011 RMS report

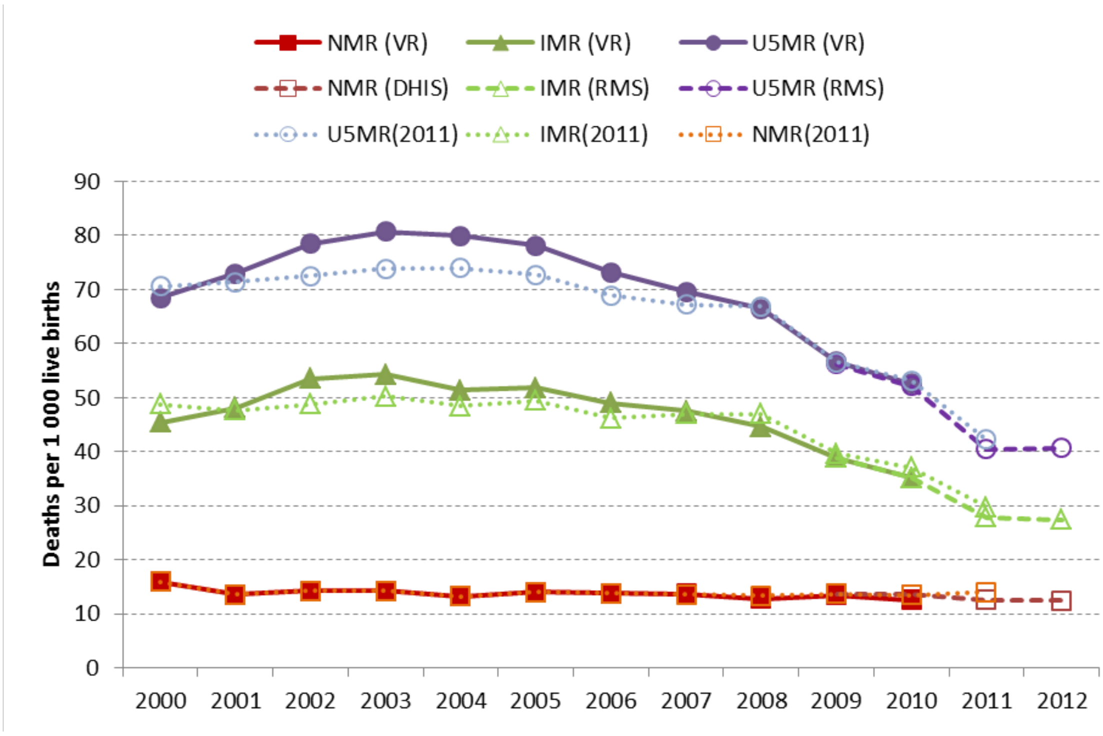

Figure 22: Comparison of estimates of infant and child mortality with those from 2011 RMS report

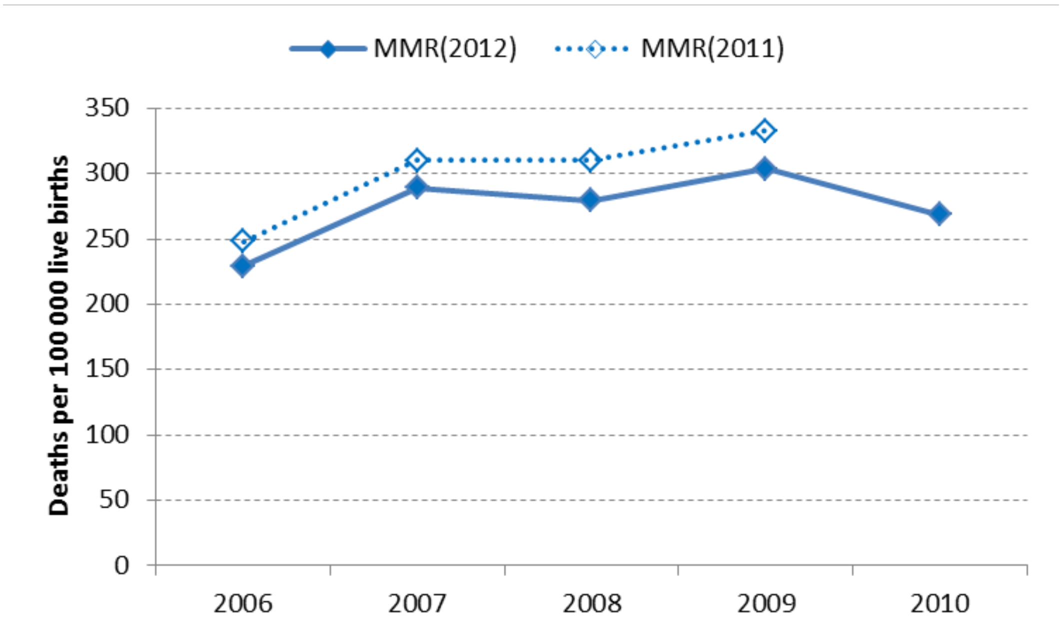

Figure 23: Comparison of estimates of the maternal mortality ratios with those from 2011 RMS report

COMPARISON WITH ESTIMATES OF OTHERS

A natural question to consider is how the estimates derived in this report compare with those presented elsewhere. Where appropriate, the RMS estimates are compared with those from Stats SA, UN agencies and the Institute for Health Metrics and Evaluation (IHME). Figure 25 compares the estimates of under-five mortality. There is broad agreement between the RMS estimates and those of IGME and IHME over most of the period, those of UN Population Division (WPP) in the first half of the period, and the MDG from 2007-2010. This correspondence suggests that rates assumed by the official mid-year population estimates are too high for most of the period, those assumed by the UN Population Division are too high for the second half of the period, and those presented in the MDG are too low prior to 2007.

The picture is similar for IMR (not presented), with the exception that relative to the U5MR, the IHME assume higher IMR (over 72% of U5MR) than do the other sources (below 68%) when U5MR is around 80, which results in the estimates being higher relative to those of the RMS. The RMS and IGME estimates are very similar for 2002-2010, after which the RMS estimate a greater decline to 2011 and then little change to 2012, whereas the IGME rates stagnate after 2010.

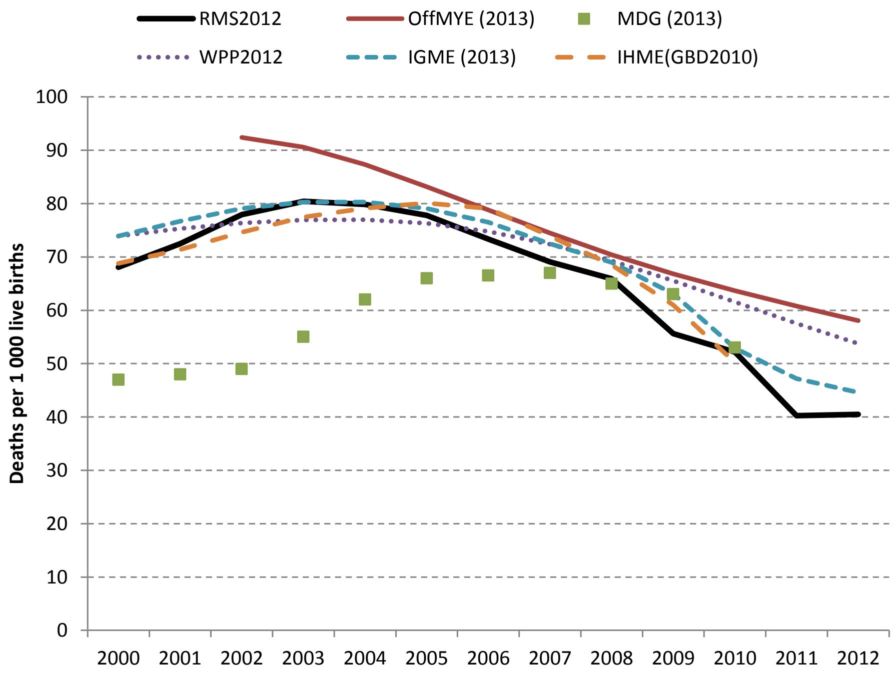

Figure 24: Comparison of estimates of the under-5 mortality rate (U5MR)

Figure 26 compares the life expectancy at birth with those from other sources, showing that while there is some consistency in the overall conclusion that life expectancy reached a minimum around 2004/2005, the estimates of the level differ. About two of years in the difference in level from the WPP life expectancies is due to higher adult mortality, the rest of the difference between the RMS and other life expectancies[3] is mainly due to differences in under-five mortality.

[3] According to the MDG report (Stats SA, 2013c), the MDG estimates are from the 2013 mid-year estimates (Stats SA, 2013d), which have been derived using the Spectrum model. However, the MDG estimates do not seem to have corrected for the fact that the estimates are not for the regular calendar year but for the year starting six months earlier, while the mid-year estimates appear to have been corrected.

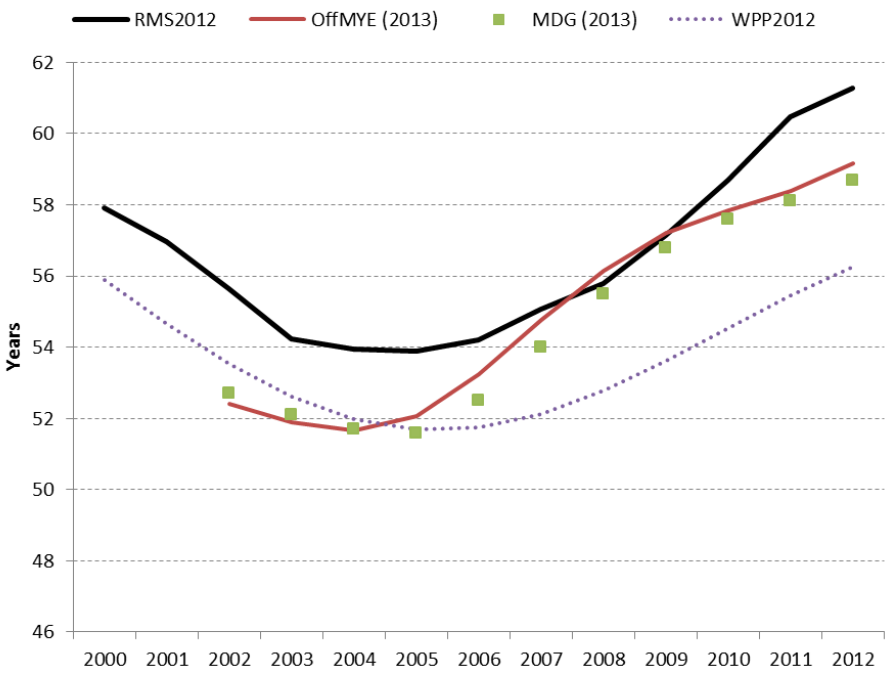

Figure 25: Comparison of estimates of life expectancy at birth (e_0)

Although there is consistency between the RMS and MDG estimates of MMR (Figure 27), this is mainly because the same method and similar data were used for both estimates. In truth, there is a great deal of uncertainty surrounding the estimates of this indicator, and not all of it is random, as reflected by the two quite different estimates produced by IHME[4] (Hogan et al 2010 and Lozano et al 2011). However, there is some consistency between the RMS, MMEIG and the older IHME estimates, putting the MMR between 250 and 300.

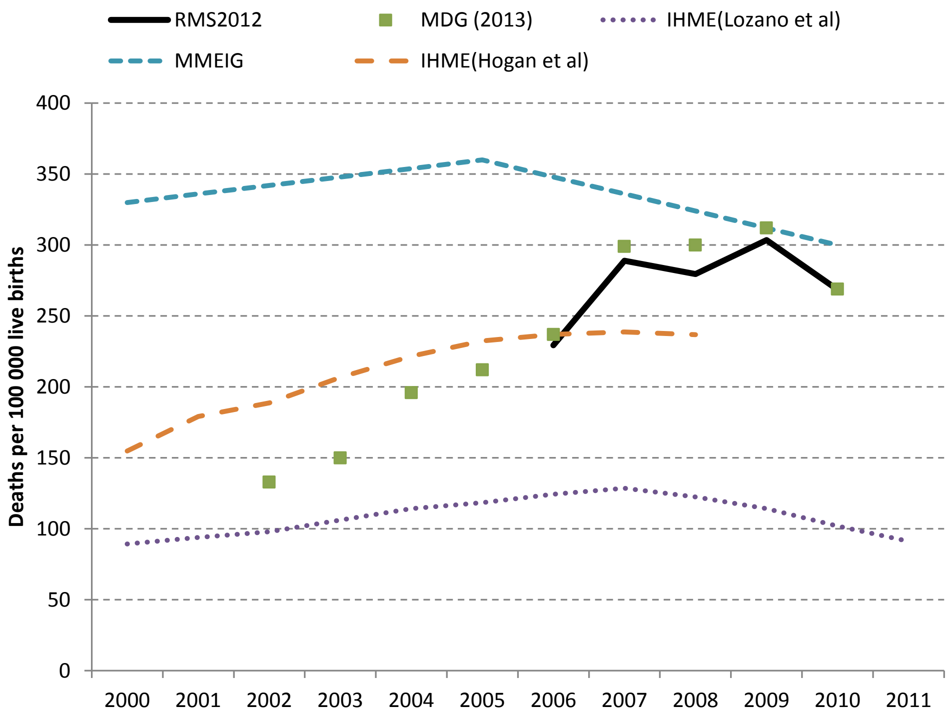

Figure 26: Comparison of estimates of maternal mortality ratio (MMR)

[4] Although usually one would simply accept the most recent set of estimates from an institution, in the case of IHME, the estimates available via their website tool are still the older estimates.

As far as adult mortality is concerned (Figure 28), the RMS estimates lie between the WPP and IHME estimates. As indicated above, the WPP lead to estimates of life expectancy that are lower than other estimates, and thus the WPP adult mortality are quite possibly on the high side.

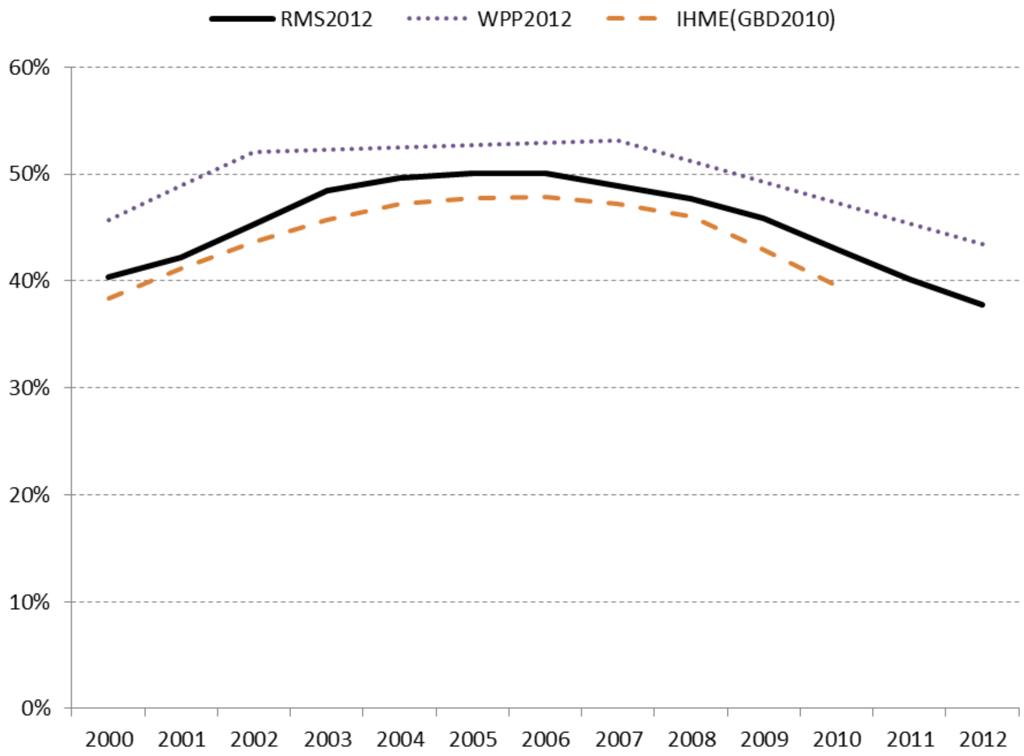

Figure 27: Comparison of estimates of adult mortality ($_{45}q_{15}$) for males and females combined

Although it is difficult to assert that the neonatal mortality in South Africa is as low as that estimated by the RMS (Figure 29), it is important to point out that the IGME, and particularly the IHME estimates, imply implausibly high completeness of reporting of post-neonatal deaths in 2010.

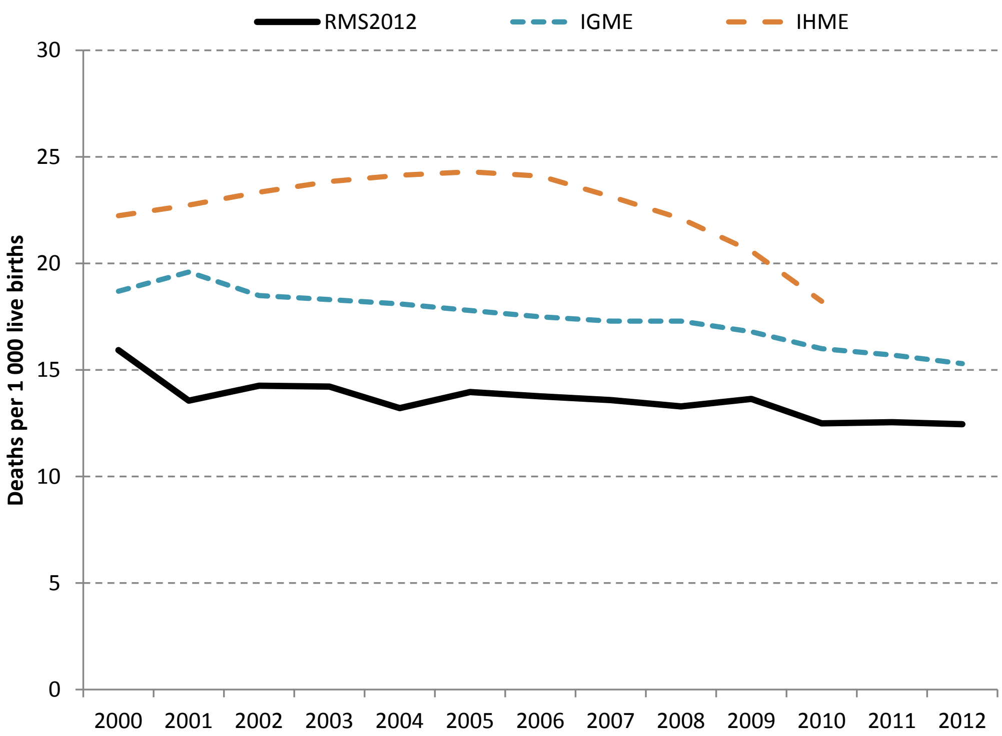

Figure 28: Comparison of estimates of neonatal mortality rates (NMR)

CONCLUSIONS

The report provides empirical estimates of key health indicators based on vital registration. By making adjustments for known bias in the number of deaths recorded on the National Population Register, it is possible to track these in a timely fashion.

The availability of population estimates from the 2011 Census made it necessary to review and revise the estimates of the population and births used in the previous RMS report. This report provides revised estimates for the period 2000-2012 using a set of population estimates that are consistent with the total population and the age structure from the 2011 Census. Ideally, the method used to produce estimates should not change from year to year. However, when new information becomes available, such as census results that suggest that fertility and migration have been significantly different in the past from what was being assumed, then one must take this information into account. The estimates of infant and child mortality, and of the maternal mortality ratio, are particularly dependent on the estimates of the number of births, which for this exercise depend on the accuracy of the estimates of the population by age from the 2011 Census. Although it is too early to tell, there seems to be some evidence that the Census may exaggerate the number of young children slightly. If this is the case, it would mean that the current RMS estimates of infant and under-five mortality, and MMR in recent years are a bit low. Thus, it is likely that it will be necessary to make further changes next year once the 10% unit record sample is released by Stats SA, since these data will allow us to derive better estimates of the population, past births and possibly to assess the reasonableness of some of the indicators.

Nonetheless, the estimates clearly show that South Africa is making progress in improving the health status of the nation and that many of the NSDA targets for 2014 have already been met or exceeded. The empirical data indicates that life expectancy has increased by seven years from 2005, reaching a level of 61 years in 2013. There have been sustained improvements in mortality of young adults and child mortality, largely due to the roll-out of ARV treatment and prevention of mother-to-child transmission of HIV.

However, neonatal mortality rates have shown little change since 2009, and the downward trend in infant and child mortality appears to have ceased in 2012. The maternal mortality ratio, which remains challenging to measure precisely, appears to have started to decline in 2010, but is still above target. There is an urgent need to review possible interventions to further reduce maternal and child mortality if the MDG targets are to be met by 2015.

Further analysis of the RMS data continues to see if it is possible to provide sub-national trends for the provinces and health districts.

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APPENDIX: ESTIMATION OF COMPLETENESS OF REPORTING OF DEATHS

Completeness of reporting of deaths is estimated in three processes for three different age ranges: infant and child mortality, adult (15+) mortality and finally the completeness of reporting of deaths aged 5-14. The process of estimating completeness of reporting deaths, particularly infant and child deaths was quite intricate and is described in broad terms. A more detailed description is scheduled to appear in the technical report on the second South African National Burden of Disease methods to be published early 2014.

Infants and children under 5 years

The numbers of registered deaths, under the ages of one and five in particular, were compared to the number expected based on estimates of the rates (q_0 and ${}_5q_0$) for specific years and applied to estimates of births for the same year. The estimates of the rates (q_0 and ${}_5q_0$) were derived from several sources including the deaths reported by households (2001 and 2011 Censuses and the 2007 Community Survey) and reports of women on the survival of their children (1998 DHS, 1996, 2001 and 2011 Censuses, and the 2007 Community Survey).

The number of births by calendar year was estimated as the number required to result in the number of surviving children at each age at the time of the 2011 Census. These numbers were used for births in the years up to 2003. From 2004, the number was estimated by scaling up the number of births recorded at public health facilities by the DHIS by approximately 25%.[5]

The completeness in individual years between the years of the point estimates of the expected number of deaths was estimated, in general,[6] by assuming that the completeness changed linearly with time between the years of the point estimates. Completeness of reporting of childhood (1-4) deaths was derived from the differences between reported and expected deaths under the ages of five and one.

Adults (15+ years)

Completeness of reporting of adult deaths was estimated by first estimating it for the following intercensal periods using death distribution methods: 1996-2001, 2001-2007 and 2001-2011. As these estimates represent averages for each period, estimates for single years were derived by fitting a logistic curve to estimates of completeness by year, derived on the assumption that it changed linearly over each period.

Children 5-14 years

Completeness of reporting by single years of age for ages 5-14 were derived on the assumption that the average of completeness for ages 1-4 was equal to that estimated for the age group 1-4 in total, and that completeness changes linearly with age between ages 1 and 15.

[5] This factor allows for the births that occur outside state facilities by matching the total number of births for 2004-2010 estimated by back projection of the numbers of people at each age in the census to their year of birth.

[6] There were one or two years where this assumption implied implausible change in rates between one year and the next, in which case the drastic change in the reported number of deaths was assumed to be due to a change in completeness rather than rate of mortality.